Performance Studies of Asphalt Pavements with Greater than 25% RAP

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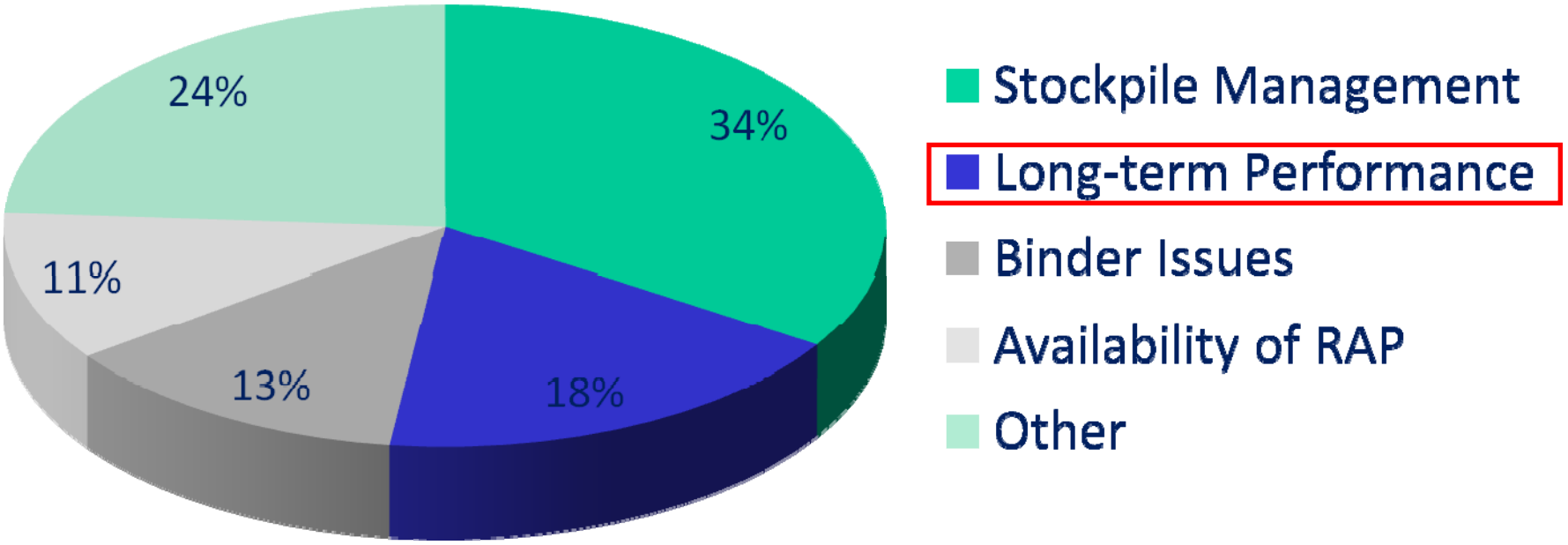
Barriers to Increasing RAP



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A Performance Comparison of RAP vs. Virgin Mixes

- LTPP SPS-5 pavement sections
- 18 U.S. states and Canadian provinces
- At least 30% RAP used in recycled mixes
- Projects range in age from 6 to 17 yrs

LTPP SPS-5: RAP vs. Virgin

- Four comparison pairs per project (location)
  - 2” overlay, no mill
  - 2” overlay with mill
  - 5” overlay, no mill
  - 5” overlay with mill
- Five performance measurements (annual)
  - Rutting, mm
  - IRI, m/km
  - Fatigue cracking, m^2
  - Transverse cracking, # per section
  - Longitudinal cracking, m
- 340 comparisons: graphed, tabulated differences, statistical analyses

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SPS-5 Experiment

Surface Preparation	Milled		Un-milled	
Overlay Thickness	2”	5”	2”	5”
Mix Type	LTPP Section Code			
RAP	509	508	502	503
Virgin	506	507	505	504

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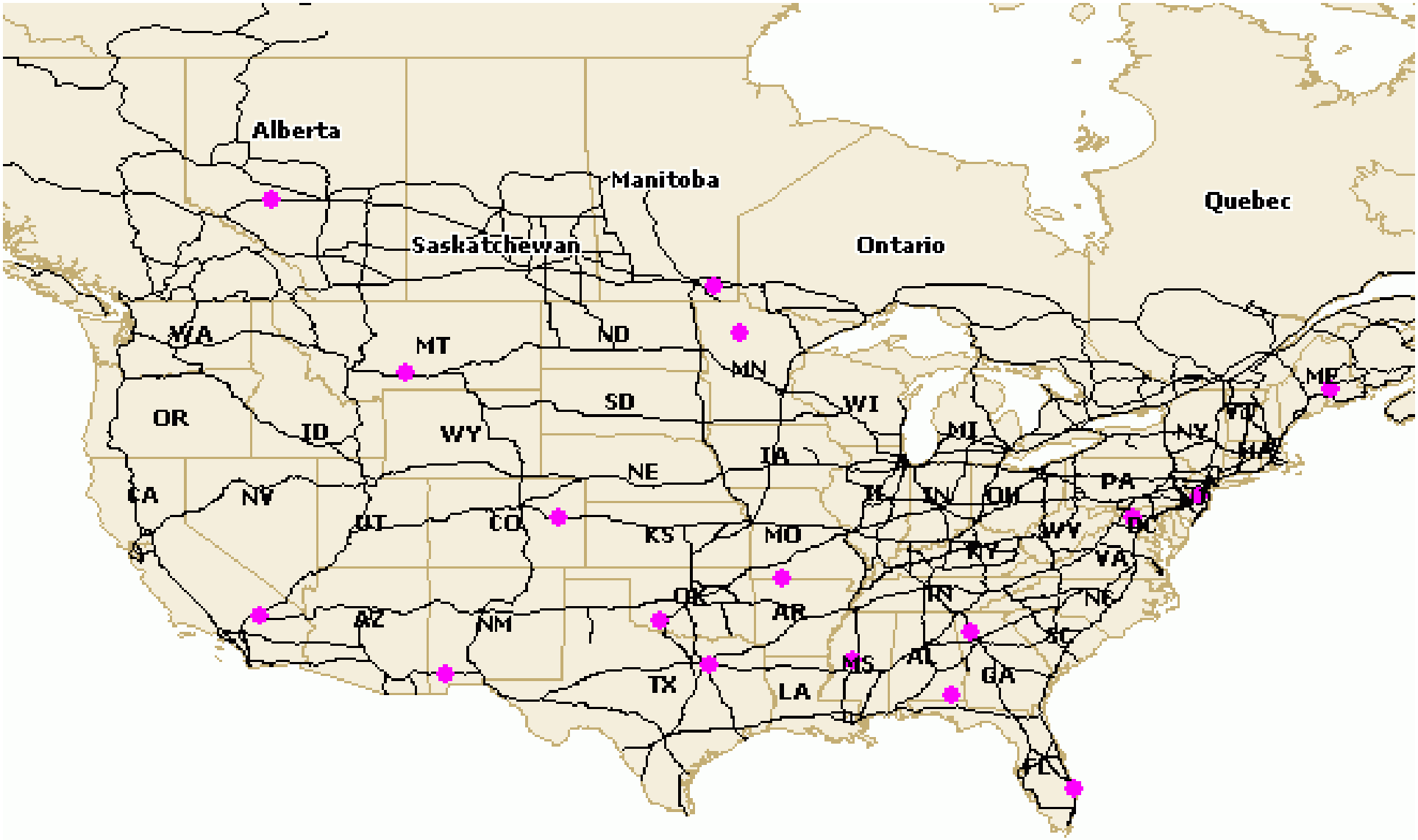
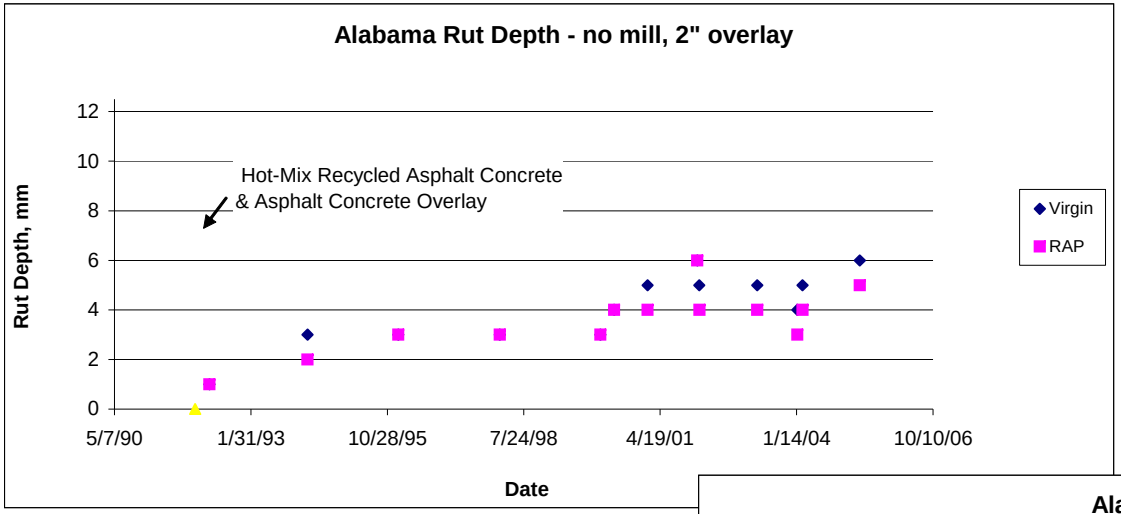
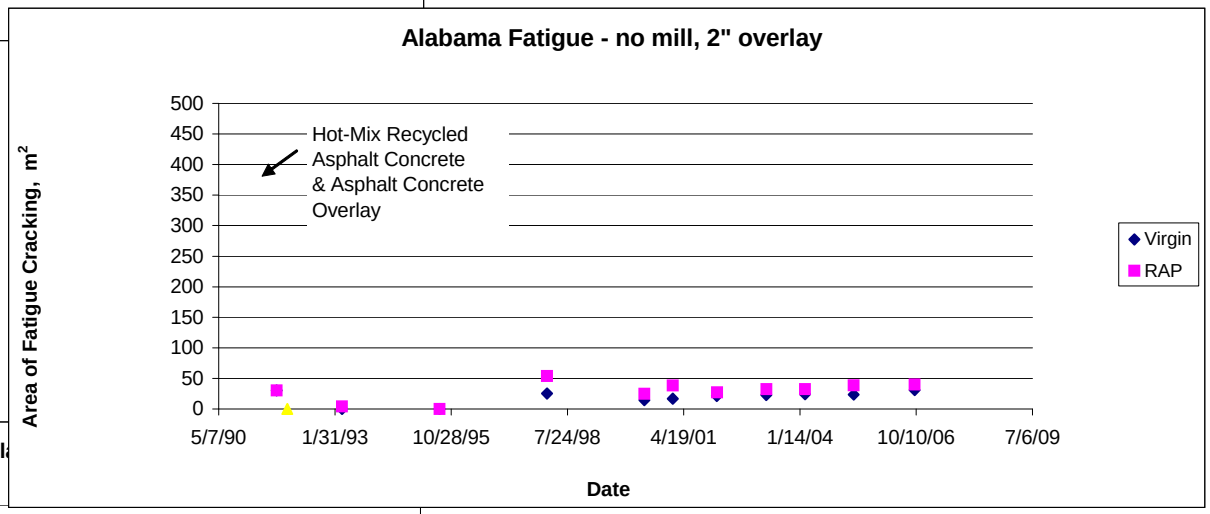
SPS-5 Project Locations

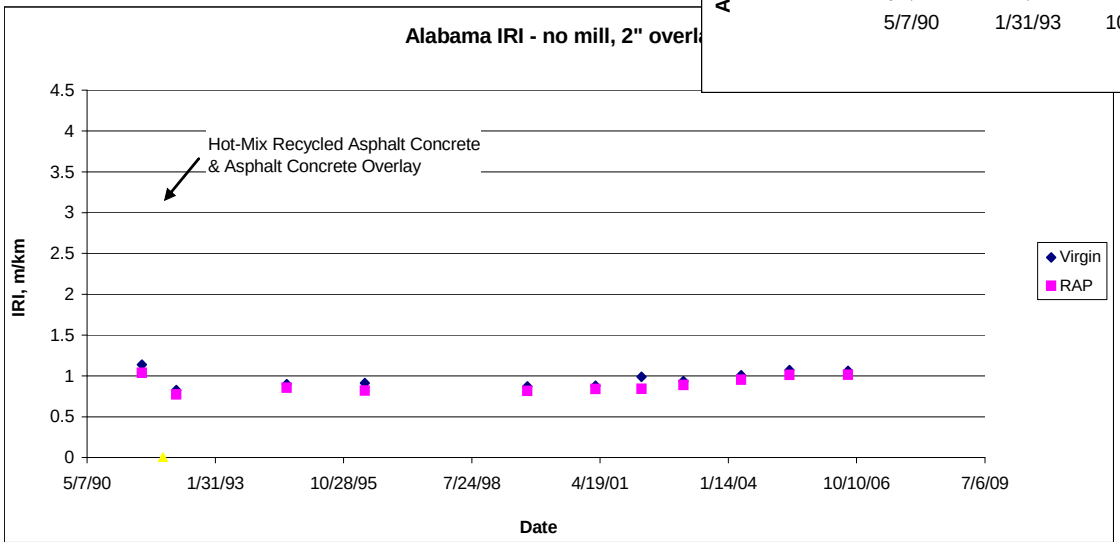


Annual Performance Data

- International Roughness Index (IRI)
- Rutting
- Fatigue Cracking
- Transverse Cracking
- Longitudinal Cracking
- Block Cracking
- Raveling







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General Performance

Percentage of Sections **Below** General Pavement Performance Thresholds			
Distress Parameter	**Threshold**	**RAP Sections**	**Virgin Sections**
IRI	2.0 m/km	86%	89%
Rutting	10 mm	71%	78%
Fatigue Cracking	25% of WP area	60%	72%
Longtnl. Cracking	25% of section length	79%	86%
Transverse Cracking	20 cracks per section	47%	64%
Block Cracking	10% of section area	89%	94%
Raveling	10% of section area	75%	69%

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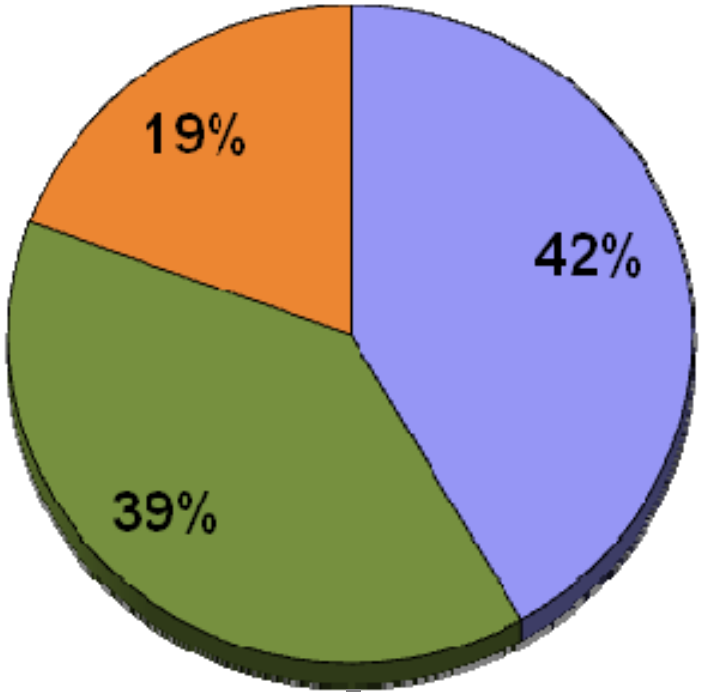
Statistical Analyses

- Paired t-test
- 18 locations x 4 comparison pairs = 72 pairs
- Alpha = 0.05

International Roughness Index



- Virgin performed significantly better than RAP
- RAP performed significantly better than Virgin
- Difference between Virgin and RAP insignificant

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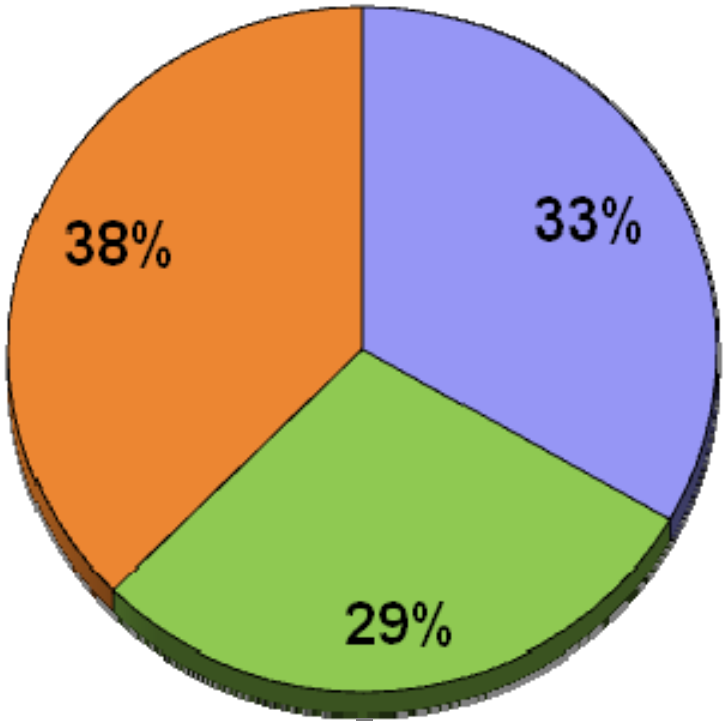
Rutting



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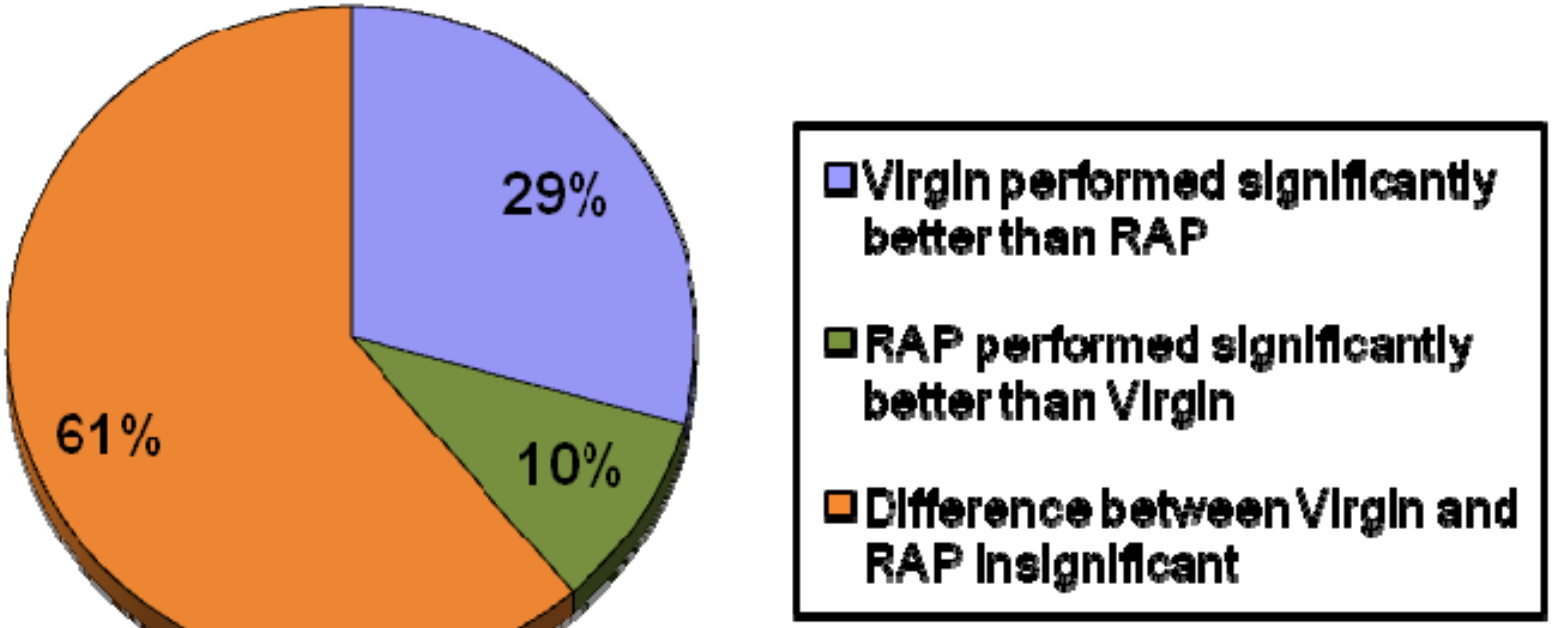
Fatigue Cracking



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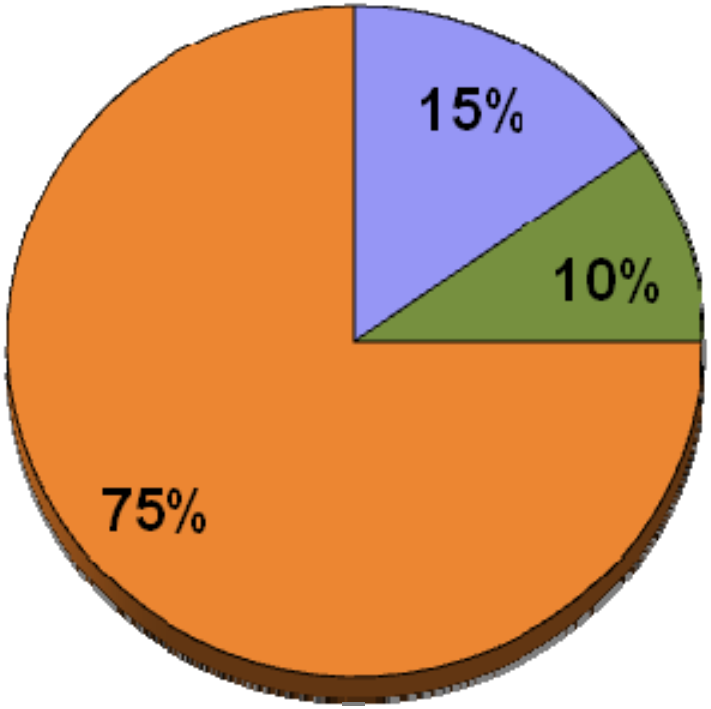
Longitudinal Cracking



- Virgin performed significantly better than RAP
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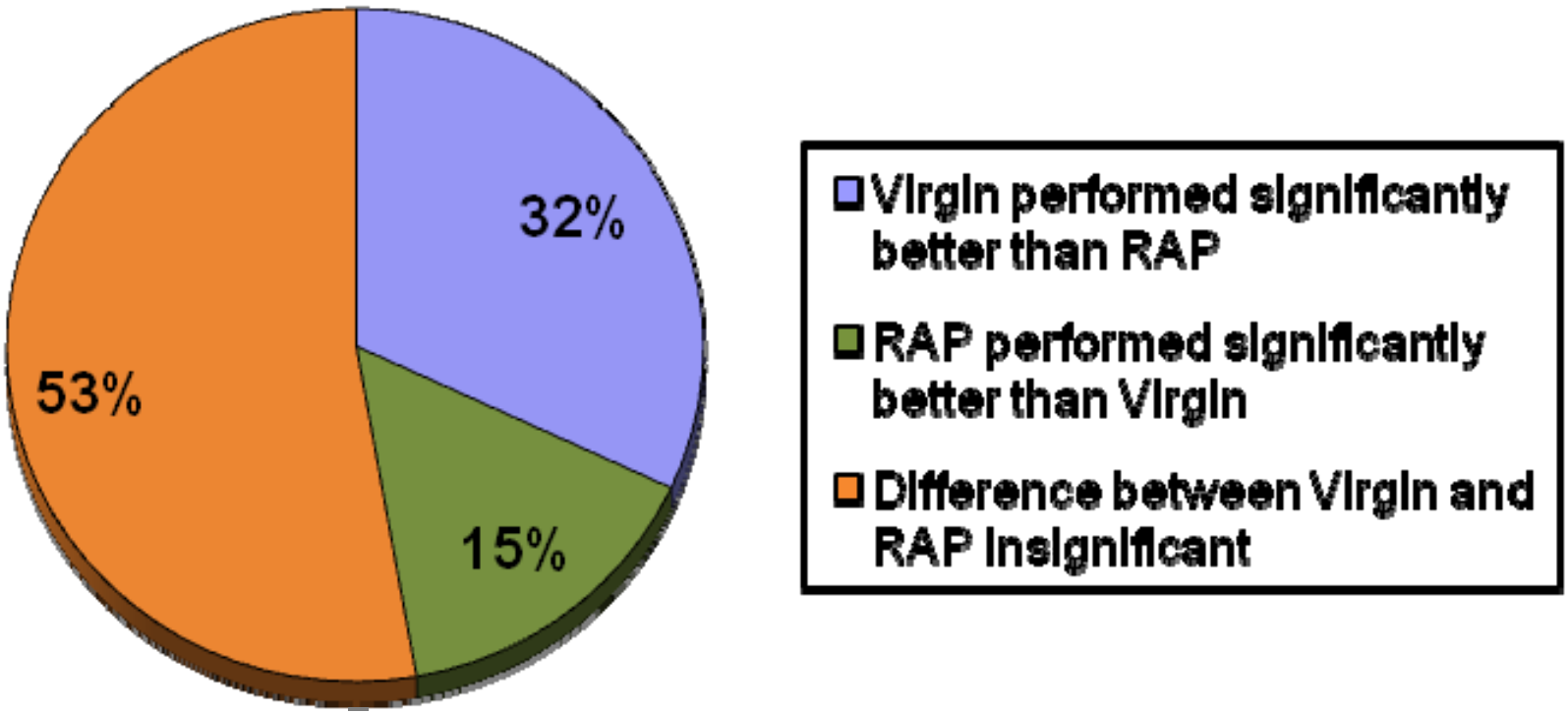
Transverse Cracking



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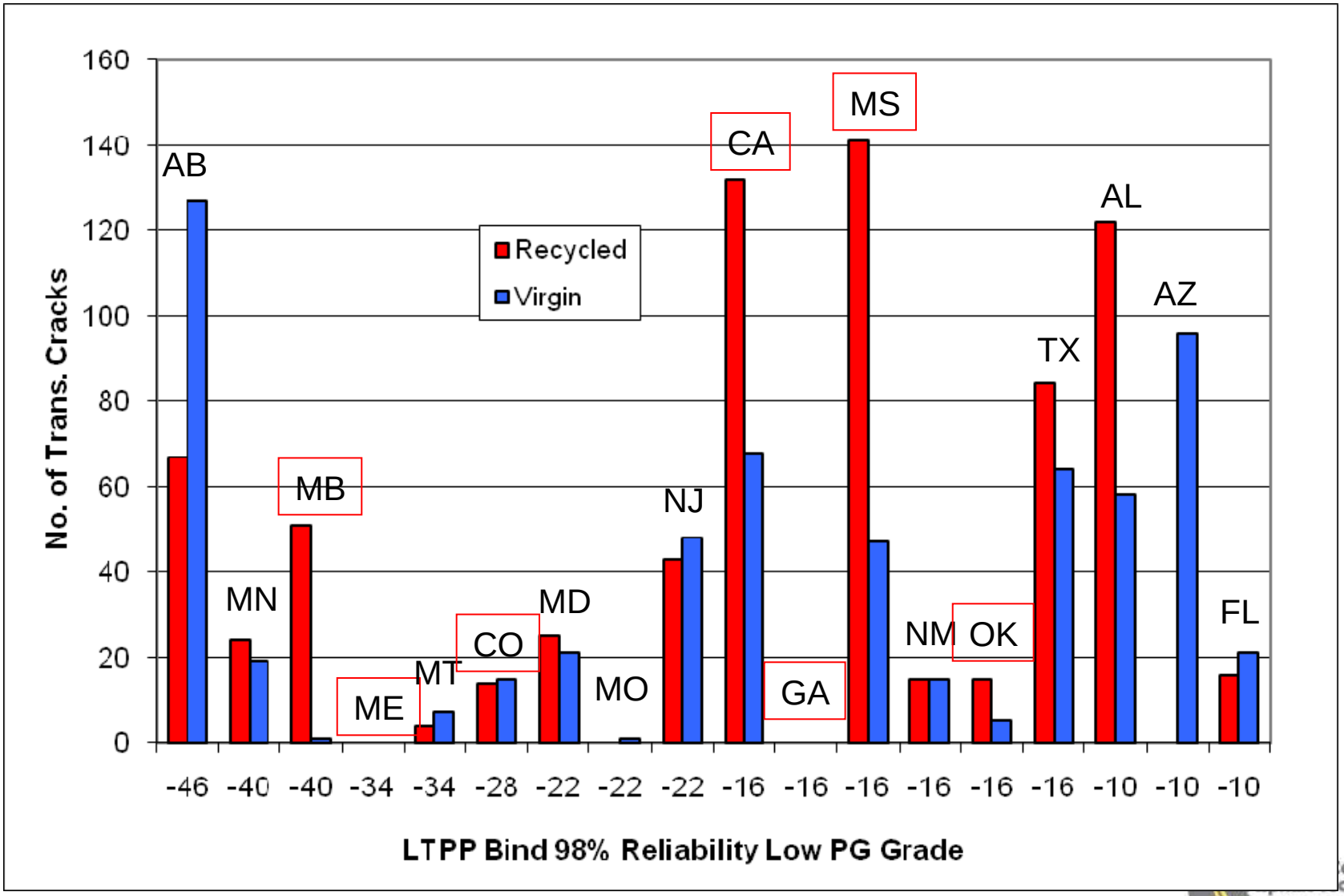
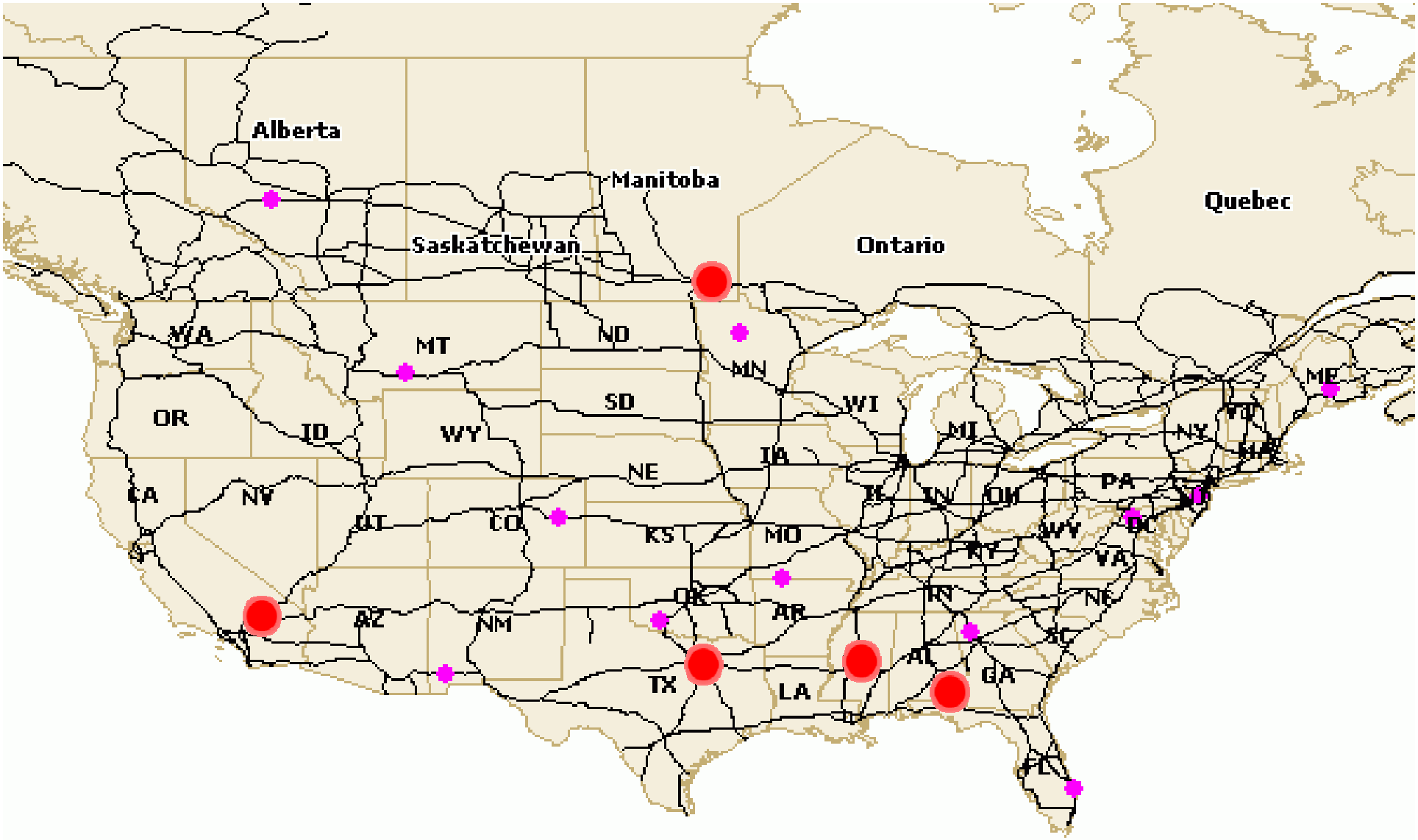
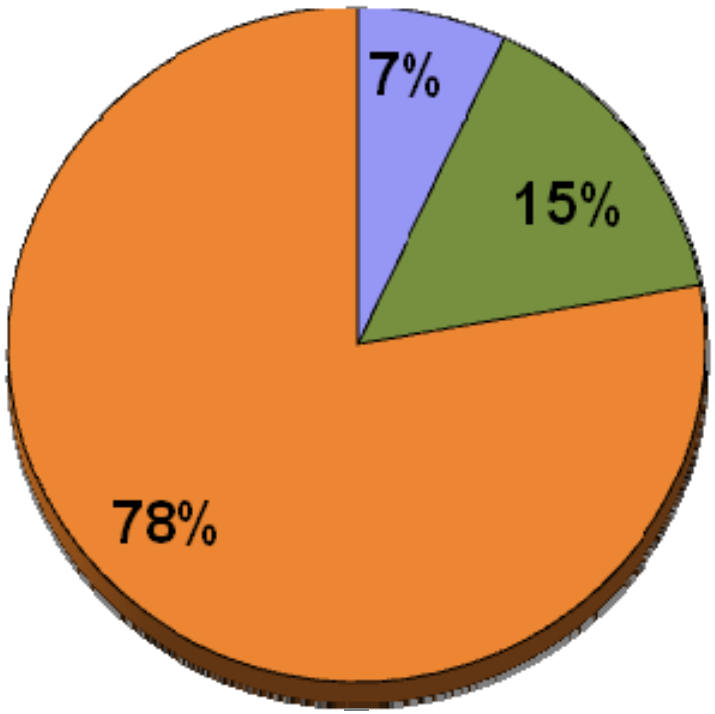


Did not use softer binder in RAP mixes

More Transverse Cracking in Recycled Sections



Raveling



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Summary of Statistical Analyses

Distress Parameter	Virgin Performed Better than RAP		RAP Performed Better than Virgin	Insignificant Difference Between RAP and Virgin	RAP Performed Equal or Better Than Virgin
IRI	42		39	19	58
Rutting	33		29	38	67
Fatigue Cracking	29	>	10	61	71
Longtnl. Cracking	15		10	75	85
Transverse Cracking	32	>	15	53	68
Block Cracking	3		1	96	97
Raveling	7		15	78	93

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Possible Causes of Higher Occurrence of Fatigue Cracking in RAP Mixes

- Lower effective binder content
- Binder is more brittle
- Lower in-place density
- Higher dust contents

Possible Causes of More Fatigue Cracking in RAP Sections

State/Province	# Pairs: Rec.>Vir.	Softer Vir. Binder in Rec. Mix?	Asphalt Content		P200	
			Vir.	Rec.	Vir.	Rec.
Alabama	2	Y	4.8	5.0	4.0	√ 5.1
California	2	N	5.3 √	3.8	4.3	√ 6.2
Mississippi	3	N	5.9	5.7	5	5
Montana	4	Y	4.8 √	3.7	5	√ 7.8
New Jersey	2	Y	4.8	4.8	n.a.	n.a.
Alberta	4	Y	5.4	5.4	8.6	√ 10.5
Manitoba	2	N	5.9	5.9	5	√ 6

CONCLUSIONS

Based on the long-term performance of a large number of projects across North America…

- Pavements using ≥ 30% RAP perform equal or better than virgin pavements in most cases
- Transverse and fatigue cracking were observed more often in some pavements with RAP compared to pavements with all virgin materials
- Differences in cracking performance for several locations may have been due to lower asphalt contents and/or higher dust contents

Thank You

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